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Comité d'évaluation des ressources transfrontalières
Comptes rendus 2013/01

Transboundary Resources Assessment Committee
Proceedings 2013/01

Transboundary Resources Assessment Committee (TRAC) Eastern Georges Bank Cod Benchmark Assessment and TRAC Benchmark Criteria Discussion: Report of Meeting held 9-11 April 2013

9-11 April 2013
Hachey Conference Centre
St. Andrews Biological Station
St. Andrews, New Brunswick, Canada

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FORWARD

The purpose of these proceedings is to archive the activities and discussions of the meeting, including research recommendations, uncertainties, and to provide a place to formally archive official minority opinions. As such, interpretations and opinions presented in this report may be factually incorrect or misleading, but are included to record as faithfully as possible what transpired at the meeting. No statements are to be taken as reflecting the consensus of the meeting unless they are clearly identified as such. Moreover, additional information and further review may result in a change of decision where tentative agreement had been reached.

AVANT-PROPOS

Le présent compte rendu fait état des activités et des discussions qui ont eu lieu à la réunion, notamment en ce qui concerne les recommandations de recherche et les incertitudes; il sert aussi à consigner en bonne et due forme les opinions minoritaires officielles. Les interprétations et opinions qui y sont présentées peuvent être incorrectes sur le plan des faits ou trompeuses, mais elles sont intégrées au document pour que celui-ci reflète le plus fidèlement possible ce qui s’est dit à la réunion. Aucune déclaration ne doit être considérée comme une expression du consensus des participants, sauf s’il est clairement indiqué qu’elle l’est effectivement. En outre, des renseignements supplémentaires et un plus ample examen peuvent avoir pour effet de modifier une décision qui avait fait l'objet d'un accord préliminaire.

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ABSTRACT

The Transboundary Resources Assessment Committee (TRAC) met during 9 – 11 April 2013 in St. Andrews, New Brunswick, Canada, to review possible assessment models for the Eastern Georges Bank cod management unit. The results of this meeting will be used to establish a new benchmark for Eastern Georges Bank cod for use in subsequent TRAC assessments.

RÉSUMÉ

Le Comité d'évaluation des ressources transfrontalières (CERT) s'est réuni du 9 au 11 avril 2013 à St. Andrews, au Nouveau-Brunswick (Canada), dans le but d'examiner les modèles d'évaluation possibles pour la zone de gestion de la morue de l'est du banc de Georges. Les résultats découlant de cette réunion serviront à établir un nouveau point de référence pour la morue de l'est du banc de Georges aux fins d'utilisation dans les évaluations ultérieures du CERT.

INTRODUCTION

The co-chairs of this Transboundary Resources Assessment Committee (TRAC) meting, Ross Claytor and Loretta O'Brien, welcomed participants (Appendix 1). The TRAC receives its terms of reference from the Transboundary Management Guidance Committee (TMGC). The TRAC review process is two tiered, with annual assessment reviews undertaken between more intensive, periodic benchmark reviews. Two previous TRAC benchmark reviews for cod were conducted in February 2002 and in 2009 (January- data meeting, April- model review). At present, the USA assessment for the Georges Bank Atlantic cod stock is conducted independently from the TRAC assessment of the eastern Georges Bank cod management unit. There is some concern that differing assessment approaches may make reconciliation of results difficult.

DISCARDS FROM THE CANADIAN GROUNDFISH FISHERY: 1976 – 1996

<u>TRAC Presentation</u>: Review of Discarding of Cod in the Canadian Georges Bank Fishery 1978 – 1996. TRAC Working Paper 2013/04.

Presenter: Don Clark
Rapporteur: Eric Gross

Terms of Reference

For the Canadian groundfish fishery operating in NAFO Division 5Z - 6 during 1978 – 1996, summarize the conclusions on discarding from the contemporary research documents, where available. Where no previous review has been done or discarding was suspected, evaluate discards (unreported catch) of cod and associated uncertainties.

Presentation Highlights

While discarding may occur for a variety of reasons related to quotas or market or fish size, the two which are perhaps most likely in a quota regulated fishery are discarding to avoid overrunning the quota for one species before quotas for other species are exhausted and discarding to avoid triggering the small fish protocol. There was little quota regulation of the Canadian Georges Bank cod fishery prior to 1995 (landings generally were well below the quota), and thus little incentive to discard, unless it was to avoid landing small fish. The small fish protocol restricted the proportion of fish less than 43 cm to less than 10% of the total catch.

Starting in 1993, annual comparisons of length composition of port samples and observer samples were reviewed as part of the stock assessment process. This was included in the assessment documents for each year. Based on this comparison, it was reported that there was no indication of discarding (high-grading) for 1993 – 1996.

Beginning in 1998, comparisons of observer and port samples indicated that discarding was considered probable (Hunt and Johnson 1999, Hunt and Hatt 2000). Discarding was also reported as a problem by some fishermen and this anecdotal information was included in the assessment. While discarding was reported as likely in the assessments, the magnitude was undetermined.

A review of existing data for 1996 – 2003 was conducted in 2004 to calculate discard rates (VanEeckhaute and Gavaris 2004). The level of discarding for 1997-2003 was estimated and this information was included in the assessment in 2004 (Hunt et al. 2004)

Since 2004, there have been annual estimates of discards of cod in the Georges Bank fishery and these have been included in the assessment (Wang and O'Brien 2012).

Discussion

There was little discussion and the conclusions of the document were supported.

Conclusions

There is no indication that there was discarding before 1998. There is a mixture of discarding and high grading now.

REVIEW OF TAGGING DATA

TRAC Presentation: Estimates of Mortality and Migration from Atlantic Cod Tag-Recovery Data in NAFO Areas 4X, 5Y, and 5Z in 1984-1987 and 2003-2006. TRAC Working Paper 2013/02.

Presenter: Tim Miller
Rapporteur: Eric Gross

Terms of Reference

Review tagging data for application in stock assessment, particularly with respect to estimation of natural mortality.

Presentation Highlights

The best performing model, as measured by AIC, (Akaike Information Criterion) was the model (M4), which allowed natural mortality rates in the Georges Bank (GB) and 4X regions and migration rates between these regions to differ between the 1984-1987 and 2003-2006 periods. However, the difference in AIC between models M3, M4, and M5 were small. There was little difference in estimated natural mortality rates from M4 on GB between the periods, but there was a much lower rate from 1984-1987 in the 4X region. The instantaneous rate of movement from 4X to GB was virtually identical between the two periods, but there was a much greater rate of movement from GB to 4X from 1984-1987. The estimated fishing mortality rates from 1984-1987 were the lowest on average in the Gulf of Maine (GOM) and the largest annual fishing mortalities occurred in 2003 - 2004 in the 4X region. Estimates of incomplete mixing effects were much larger in the GOM than elsewhere, and tag-induced mortality estimates were between 25 and 30% of the releases depending on the regional fishing mortality and incomplete mixing effects. Fitting the same model structure as M4, but with a range of assumed reporting rates for high-reward tags showed that the log-likelihood was largest when complete reporting was assumed. As expected, natural mortality rates declined and fishing mortality rates increased as high-reward reporting rate declined although the degree of difference varied among regions and years. Effects of the high-reward rate assumption on migration rates varied in direction and magnitude. There was little or no effect of the high-reward reporting rate assumption on the estimated tag shedding rate or low-reward reporting rate. However, the tag-induced mortality and incomplete mixing effects increased as high-reward reporting rate declined. The reason the goodness of fit declines with lower reporting rate is unclear but may be caused by certain parameters, such as the tag-induced mortality being constant when there are important differences by release category. The tag-induced mortality estimate increased as the high reward reporting rate was increased, but the precision of this estimate also decreased implying that the ability to estimate this parameter declines with the high-reward reporting rate.

There could be a marked difference in survival when fish to be tagged are captured by hook and line rather than trawl gear.

Discussion

A number of questions on the analysis guided the discussion:

- There was discussion on how M estimates changed between models. We examined the results from the models and found little difference among them.
- The continuous time aspects of the model allows for estimation of parameters. However, fishing mortality is assumed constant in each year despite seasonal nature of fishery.
- Can seasonal movement give an appearance of increasing M?

Tag reporting rates have likely influenced the results:

- There was a lack of confidence that reporting rate was 100%.
- It was noted that a decrease in high reward reporting rate was correlated with a decrease in M.
- What was the difference between low and high reward amounts in the reporting rate study?
- There were no high rewards in 1980s although there was a $5 Canadian low reward. More recently there have been T-shirts or other incentives as well as entry into a lottery for $200, and a reward tag for $100 US.
- Tag reporting doubled when the incentives increased.
- Fishing industry involvement with the project yielded better return rates.

Size of cod in analysis:

- The analysis included only fish 50 cm and larger because large numbers of fish <50 cm were tagged in one small area of GB.
- In the 1980s, age 6 fish were about 80 cm and currently are about 70 cm.
- The lack of tags on older fish could be influencing the results.

Uncertainties

Explanations discussed for the unknown bias on estimated M included:

- Confounding of variables: tag related mortality, F, and M.
- Regions differing between time periods.
- The time of year fish are tagged relative to life-history:
  - Mortality and temperature
  - Movement and seasonality
  - Commercial versus tagging trips.
- Effort changes in fishing:
  - Time periods, areas
  - F assumed constant in model but occurs discretely.
- Tagging-induced mortality sensitivity was not looked at but there was a likelihood
  - Not many tags were returned (6,000 from 78,000)

    - How was shedding rate managed? : lose one tag, more likely to lose other tag, assumption of independence is not met.
- Shift in size of older fish, i.e. age 6 fish were 80 cm in early time period, now 70 cm more recently.

Upper Bound is an overestimate of M due to:

- Equal tag shedding rates: positive covariates, if lose one tag, fish more likely to lose the other tag, thus assumption of independence is not met.
- Underestimate of tag loss rate given that that fish go from 2 tags to zero tags faster than independence assumption.
- Change in motivation for returning tags; changes in rewards are confounding the reporting rate.
- Assumption of model that reporting rate of low tags is the same as the higher reward incentives, but see above. This would overestimate M in previous time period.
- Movement to areas outside of model likely would occur infrequently but would result in small positive bias.

Strengths of this analysis were noted:

- Uses published methods.
- Two time periods.
- Two regions.
- Makes maximum use of data to date, more than is typical for M for groundfish in general.
- Encourage analysis to continue – likelihood profiling and other diagnostics could be included, simulation studies to look at assumption biases.

Conclusions

Analytical Results

- Analysis indicates that M has not changed over time on GB.
- M high (approximately 0.8) in both time periods on 5Z.
- M low on 4X early period, high in later period.

Interpretations

- Estimates are considered as upper bounds, given this is the way bias works in these tagging models (see sources of uncertainty).
- Positive bias in most recent period is less than the early time period
    - The 1980s model fit required the assumption that reporting rate was constant for low reward tags.
    - Reporting rate would likely be too high for the 1980s.
    - F estimates for 1980s lower than model estimates.

HISTORY OF ASSESSMENT FORMULATIONS

TRAC Presentation: History of Eastern Georges Bank Cod Assessment Formulations

Presenter: Yanjun Wang
Rapporteur: Eric Gross

Term of Reference

Explore a full range of pertinent assessment methods for estimating current abundance and exploitation rate, in particular, to address the issue of retrospective bias.

Presentation Highlights

For the purpose of a sharing agreement and consistent management by Canada and the USA, agreement was reached that the transboundary management unit for Atlantic cod would be limited to the eastern portion of Georges Bank (DFO Statistical Unit Areas 5Zej and 5Zem; USA Statistical Areas 551, 552, 561 and 562). The fishery catch at age, including discards, for 1978 to 2011 and the bottom trawl surveys, conducted annually by DFO and NMFS, are the information used to conduct the assessment. Evaluation of the state of the resource was based on results from an age structured Virtual Population

Analysis (VPA). The VPA was calibrated to trends in abundance from three bottom trawl survey series: NMFS spring, NMFS fall and DFO.

For a basic VPA calibration, the annual natural mortality rate, M, was assumed constant and equal to 0.2 for all ages in all years. Fishing mortality on age 9 for 1978 to 2011 was assumed to be equal to the population number weighted average fishing mortality on ages 7 and 8. The estimated model parameters were population abundance in the terminal year and survey catchability at age. The basic VPA calibration displayed notable age and time residual patterns. However, the greatest concern was caused by a persistent retrospective pattern, which indicated that contemporary estimates of biomass were consistently lower than previously estimated.

The 2002 benchmark formulation was otherwise similar to the basic formulation except that it also estimated population abundance at age 10 for 1999 onwards, the so called ”around the corner” approach. With the inclusion of information for additional years, the assessment results exhibited a domed catchability pattern by age in both the DFO and NMFS spring surveys, and the descending limb of the fishery partial recruitment curve became increasingly steep for older ages. The resulting assessment generated appreciable ‘cryptic’ biomass that could not be observed by either the fishery or the surveys.

An Eastern Georges Bank cod benchmark assessment was conducted in 2009 to address these concerns. An examination of the implications of eliminating the first quarter fishery indicated that the magnitude of those removals was not large enough to appreciably alter fishery partial recruitment after the mid-1990s, a key feature of the 2002 benchmark model formulation. At the 2009 benchmark meeting, the “split M 0.5” model (with a split in the survey time series (1993/1994) and constant natural mortality of 0.2 except when M=0.5 for ages 6+ after 1994) appreciably improved the time trends in residual patterns and reduced retrospective patterns compared to the basic VPA. While this model was supported by fit diagnostics, persistence of higher natural mortality was questionable. It was recommended during the 2009 benchmark review meeting that the results from the comparable “split M 0.2” model, which was otherwise similar to the “split M 0.5” except that M=0.2 for all the ages and years, also be considered for providing management advice.

With the inclusion of information for additional years, the persistent strong retrospective pattern was a problem for both models in the recent assessment. The retrospective analyses showed a tendency to overestimate age 3+ biomass and underestimate F in recent years. Meanwhile, a mechanism that explained the abrupt change of survey catchability in 1993/1994 could not be established. Furthermore, catches in recent years based on these models have not reduced fishing mortality below Fref which is not consistent with recent fishery management actions.

It was agreed at the 2009 benchmark meeting that documenting the fate of the 2003 year class, the only year class near average since the 1990 year class, should be informative about natural mortality at older ages. The calculated total mortality, Z, for ages 6+ for the 2003 year class, was appreciably high; i.e. 2.25 from DFO survey (ages 6-9), 1.38 from NMFS spring survey (ages 6-8) and 1.46 from fishery catch (ages 6-8). An analysis which involved tracking each cohort indicated that Z on ages 6+ is currently as high as or higher than prior to the mid-1990s. A covariance analysis with a 4-year moving window showed a similar trend.

In summary, the following data features should be considered in developing a new benchmark model:

- Total mortality calculations indicate that Z has remained high for ages 6+.
- Total mortality appears higher for ages 6+ compared to ages 4-5.
- Relative exploitation (catch/survey) shows a decline beginning in the mid-1990s
- The trends in total mortality, coupled with relative exploitation, imply that natural mortality has increased since the mid-1990s and that M may be higher at ages 6+.

Discussion

This Z analysis on cohorts, a model-free approach, strongly points to Z’s on average of 1-1.5. How believable, biologically, is it to have Z this high? Do we believe it is M or F or something else? Another explanation could be movement out to areas of unavailability (corals, or away from fishing effort). However, this would imply also that they are not spawning, since we are not detecting incoming year classes. No evidence that fish have moved to Iceland, and there is effort everywhere, so the fish would be seen if they were in Canadian waters. High Z has been reported for white hake, cod, plaice, and 3 skate species in the sGSL. For haddock, the older ages are also declining faster than predicted, and it is creating domed selectivity (as low as 0.3 on plus group). While cod may outswim trawls, they cannot avoid gillnets or longlines. Cod are rarely observed beyond age 6. This is problematic for management, due to the two extreme options: fish them hard because they will die, or don’t fish and wait for them to come back. A caveat to the former option (fish hard) is the possibility that Z (ultimately M) can drop in the future.

Conclusion

Several factors support that a higher M is plausible but the meeting did not reach consensus that all the non-stationarity was the result of increase in M. The list of factors includes:

- Condition: Fish condition in two winter/spring surveys has declined.
- Predation: High M of cod in the sGSL has been attributed to predation by grey seals. Based on satellite tagging, adult males from the Sable Island herd (which has increased in abundance over the past 20 years) forage on Georges Bank in winter.
- High M in other areas plausible (ESS, sGSL) where Z remains high even when fishing does not occur.

NATURAL MORTALITY RELATED ECOLOGICAL DATA

TRAC Presentation: Eastern Georges Bank Cod Natural Mortality-Related Ecological Information

Presenter: Yanjun Wang
Rapporteur: Liz Brooks

Term of Reference

Examine relevant ecological and biological data such as, but not limited to, growth, maturity, fecundity, recruitment, environmental factors, and trophic interactions to estimate natural mortality.

Presentation Highlights

The survey data were used to evaluate trends in biological attributes. Both the DFO and NMFS spring surveys showed that there has been a declining trend in length and weight at age since the mid-1990s. Results from fitting length at age data to a von Bertlanffy growth function indicated that the current population is dominated by relatively small fish with high K and low Linf. The assumption is that smaller fish are subject to higher predation than larger fish. Fulton's K (round weight at age/length at age3) of post-spawning fish, was used as an indicator of fish condition and indicated a clear downward trend for both DFO and NMFS spring surveys. There was no clear trend in condition for the NMFS fall survey series. There is a seasonal cycle in condition in these cod, with condition lowest in the spring following a period of limited feeding. Thus, poor condition would be expected to be most evident in the spring and less evident in the fall, during the summer/fall feeding season. This makes it difficult to draw conclusions on trends in condition from fall survey data. Fulton's K calculated using gutted weight from cod sampled during the 2013 DFO survey indicated that most fish > 55cm had a condition factor below 0.8, a value near those of fish in the starvation experiments in the lab (<0.7, Lambert and Dutil 1997). Maturity at age data, bottom temperature and salinity from DFO and NMFS spring surveys did not show notable trend.

Based on diet analysis, clupeids, sand lance and silver hake are important fish species in the diet of cod on GB, and overlap with the diets of some large pelagic species and mammals like swordfish, seals, sharks and spiny dogfish. It was suspected that competition for food might contribute to the elevated M of cod on EGB due to the increased population numbers of some of these competitor species.

Although it has been reported that predation of cod by other fish species, based on data collected during bottom trawl surveys, is not common, cod is a major diet item of grey seals throughout their distributional range. Grey seals range widely and the population on Sable Island continues to grow exponentially (O'Boyle and Sinclair 2012). Analysis of grey seal tagging data indicates that adult males from the Sable Island herd forage seasonally on Georges Bank and neighbouring waters in winter and early spring (February-April) (Breed et al. 2006). Also, the local harbour seal populations off New England have become more abundant during the last few decades. The fishing industry reports multiple observations of "belly biting" of larger cod, even in the absence of fishing gear (Rafferty et al. 2012). Predation by seals was suspected as another important contributor to recent high M of cod on EGB.

An analysis of Georges Bank cod tagging data from 2003-2006 showed that M on cod > 50 cm FL is at least 0.4. This M is in the context of a closed management unit area and could be a proxy for fish emigration or leakage to adjacent areas (4X or west GB).

Discussion

- 2013 survey plot of condition—could this decline with length coincide with change to maturity and ontogenetic diet switch? Also, some fish stop eating prior to spawning, so it may be that mature cod stopped eating and this affected their condition suggesting that when condition < 0.7, there is high risk for natural mortality (Lambert and Dutil 1997).
- Inferring abundance of large pelagic predators by looking at their landings trend is not an appropriate method to infer abundance increase.
- No catch of old fish in fall survey – the fish are on the edge of the Bank in the fall, and older fish have never shown up in the fall survey; however, in the following spring older fish show up, so their absence in the fall does not indicate their absence in the population.
- The reference to “High M” refers only to recent years. Fish size has been observed to decline in recent years, and is hypothesized to link to an increase in M, although empirical support has not been demonstrated.
- Regarding the satellite tagging study (map from Breed et al. 2006)—the seals only appear to be on Georges Bank during Feb.-March. Only 41 males and 41 females tagged, and the map shows predominately large males (yellow color on map) on GB in Feb-Mar. Is there a rough estimate of how many cod a male seal could consume daily? What sort of removals could be expected in those 2 months? Data was not available to address this at the TRAC. At the NEFSC benchmark review of cod on Georges Bank and in the Gulf of Maine, Gordon Waring discussed diets from analysis of some gillnet caught seals—they found gadoids such as red and white hake, which they identified from the otoliths, but no cod otoliths. Observations from fishermen coincide with seals being on the spawning grounds. So why do the seals not prey on haddock, which are much more abundant?
- The argument is being made for higher M, and condition factor in the spring is supporting this claim, but it could also be pointing to changes in selectivity and catchability. It will be important to keep those in mind.
- With respect to cod feeding: if cod are opportunistic, they would feed on whatever was most abundant. Is there a preference for clupeids because of the high energy content? The spatio-temporal data available to examine differences in diet composition on GB (east vs west, e.g.) are probably not sufficient for fine-scale detailed analysis.

TRAC Presentation: A Population Model for Eastern Georges Bank Atlantic Cod Incorporating Estimated Time Trends in Natural Mortality. TRAC Working Paper 2013/03.

Presenter: Doug Swain
Rapporteur: Liz Brooks

Presentation Highlights

VPA models incorporating random walks in M are a solution to the retrospective problem in assessment models of EGB cod. These models do not require a “split” in the survey time series. In fact, when random walks in M are incorporated in models, models without a “split” in the survey time series provide a more reliable fit to the EGB cod data than models with a split, at least in terms of retrospective patterns. VPA models which estimate time trends in M could be implemented in ADAPT (Gavaris 1999) by estimating 6+ M in blocks of about 5 years beginning in about 1991. Examples of this approach are given in Chouinard et al. 2005 and Swain et al. 2009b.

When a split in the surveys is allowed in 1994, catchability increases sharply for all surveys even though there were no changes in the surveys. This would imply a substantial change in the distribution of cod between 1993 and 1994, consistent across all seasons (winter, spring and fall), resulting in a large increase in availability of cod to the surveys. Is there evidence for such important changes in cod distribution?

Even when a split in the surveys is employed, estimated M of ages 6+ increases to levels near 1 in recent years. When no split in the data is employed, 6+ M estimates increase to a level near 1 from the mid 1990s to the mid 2000s and then increases again to levels above 1.5 in recent years. Such high levels of M might be considered implausible for a large-bodied demersal fish. Yet, estimated M has increased to unusually high levels for adults of large-bodied demersal fishes throughout the marine fish community in the sGSL (e.g., Benoît and Swain 2011). For example, M of adult white hake in the sGSL is estimated to now be about 2. Similarly, M of eastern Scotian Shelf (ESS) cod 5 years and older increased to about 1 in the early 1990s (e.g., Swain and Mohn 2012).

Possible causes of elevated M have been examined in detail for cod in the sGSL (Swain et al. 2011). Hypotheses examined included unreported catch (i.e., some of the increased mortality is unknown fishing mortality, not natural mortality), emigration (i.e., older fish are leaving the ecosystem, not dying), or increased natural mortality due to disease, contaminants, poor fish condition, life-history change (early maturation, early senescence), heavy parasite loads, or increased predation mortality. There was no support for most of these hypotheses. Unreported catch may have been an important component of the increased mortality attributed to natural causes in the late 1980s and early 1990s, but this source of mortality was deemed negligible since the late 1990s due to the very low levels of fishing effort since then. Early maturation in combination with poor fish condition may have contributed to increases in natural mortality in the early to mid 1980s but neither factor was supported as an important cause of elevated natural mortality in the 2000s. The weight of evidence most strongly supported the hypothesis that predation by grey seals is a major cause of the elevated natural mortality of cod.

Increases in M of cod and other large-bodied demersal fishes in the sGSL have been coincident with dramatic increases in the abundance of grey seals. This has occurred at a time when the biomass of these fishes is severely depleted; suggesting the hypothesis that increases in M may be partly due to a “predator pit” or predation-driven Allee effect (Gascoigne and Lipcius 2004). In the sGSL, satellite tagging data indicates that grey seals, in particular adult males, forage in the vicinity of overwintering aggregations of sGSL cod (Harvey et al. 2012). Diet samples taken from these seals contain a high proportion of cod (e.g., 64% - 75% of the energy in intestine and stomach contents, respectively; M.O. Hammill, unpublished data). Based on the otoliths found in digestive tracts of seals, a high proportion of the cod in the winter diets are the larger cod with elevated M in the southern Gulf population (e.g., DFO 2011). Due to wide spatial, seasonal and individual variation in the diet of grey seals and spatial and seasonal gaps in the diet samples, it is not yet possible to reliably estimate the percent contribution of predation by grey seals to the elevated natural mortality of southern Gulf cod. Nonetheless, based on the energy requirements of seals and estimates of their spatiotemporal overlap with sGSL cod, Benoît et al. (2011) concluded that it was plausible that predation by grey seals could account for a high proportion of the natural mortality of cod, even if their contribution to the average seal diet was modest (15%).

Based on satellite tagging, a high proportion of adult male grey seals from the Sable Island herd forage on Georges Bank and neighbouring waters in winter and early spring (February-April; Breed et al. 2006). In diet studies in the sGSL, consumption of large demersal fish is greatest in the adult males. This suggests that predation by grey seals should be considered as a possible factor contributing to elevated M of EGB cod.

If predation is an important component of the elevated M of EGB cod, it seems suprising that M is elevated only for cod 6 years and older. In the sGSL and on the eastern Scotian Shelf, M is elevated for cod 5 years and older. These age groups include cod the size of EGB cod aged 3 years and older. However, in the sGSL, increases in M are much greater for older cod in the 5+ group than for younger cod in this group (e.g., Swain et al. 2009b). One possibility is that this reflects differences in cod abundance and grey seal prey preferences between cod size groups.

Discussion

What happens in the retrospective M plot for model 3 when it switches from constant to changing M? In Model 3, the non-stationarity in the data beginning around the early 1990s can initially be accounted for by splitting the RV time series (resulting in an increase in q). However, the non-stationarity continues to occur, and by the mid-2000s the split in 1993-1994 is no longer sufficient to account for it, and the model accounts for the continuing non-stationarity by increasing M. The alternative would be to split the RV time series again in the mid-2000s.

Seal mortality looks plausible based on reviewed seal tagging studies. A Random walk on M is troublesome for such a hard to estimate parameter, it could be absorbing all of the lack of fit. This effect would be particularly important to investigate for the estimates that have M increasing sharply at the end of the time series. Initially, in earlier models for sGSL cod, M was estimated in blocks, and this approach indicated the same increasing trend in M as indicated by models using a random walk. There is some concern about splitting the ages at age 6, why should 6+ be so sharply different from ages 5 and below; more specifically why such a dramatic change between 5 and 6. With 3 M age groups, the middle group (3-5) did not have a tendency to increase, either.

How sensitive are results to the chosen prior for M? Or to the standard deviation assumed for the Mdevs? The model has freedom to move away from the initial prior if warranted by the data. The estimated M trend will be smoother with fewer fluctuations if a smaller standard deviation is assumed.

Regarding equation 2, there is a preference to see it bias corrected. The DFO q that increases through age 8 is hard to understand; why not just put a flat q from age 4 onwards. Perhaps make it flat for all three surveys from age 4 onwards.

When adult M is very high (e.g. 2 or greater for white hake in the sGSL), recruits per spawner must be very large in order for the population to persist. Based on the RV survey, recruitment rate is indeed now exceptionally high for sGSL white hake. This may be partly due to reduced cannibalism since adult white hake, the main piscivorous fish in inshore areas of the sGSL, have declined to very low levels of abundance. For sGSL cod, which also has very high adult M, recruits per spawner are not increasing, and SSB is declining.

On the objective function slide, none of the standard deviation parameters are estimated, they are fixed a priori. What is limiting our ability to estimate consumption? Spatial and seasonal gaps in diet observations are limiting our ability to estimate consumption. Any idea if hypoxia in the sGSL could affect their feeding? In contrast to the St. Lawrence estuary, it is not a problem in the sGSL.

Is the Mstd constraining the Mdev estimates so that the CI looks tight? Typically it is difficult to estimate selectivities for old fish when there are none, so why is M estimated so precisely? Were the gradients very small? Does the retrospective indicate that those parameters were well estimated or not? It seems that the disappearance of old fish is so quick that it allows the model to hone in on the correct M. The gradients were all very small.

Did you look at the magnitude of implied biomass lost to M? It might be useful to get an idea of the scale.

Re-run Discussion

Forcing a flat-top to the survey q does not have much impact on the M estimates. The DFO survey is the shortest time-series of the three, so it may not be able to influence the results greatly.

The results suggest M increases with time, so using a single sudden change in M is doomed to failure, since the “average” M over the recent period will change with duration of the recent period.

The dramatic difference between ages 1-5 and age 6+ was troubling to reviewers – what is the mechanism for such a change? It is likely that the change is not sudden and at one age, but adding and dropping ages from the plus group was thought to likely not help us reach a conclusion on what is happening.

A summary of how many cod that seals might be eating suggests seals could be eating several times more cod than the fishery captures, depending on how many males are going to Georges Bank in February. It is not clear how many may be there.

The amount of missing fish is several times the level of the reported catch. It seems unlikely this could all be due to unreported catch. Whether seals are responsible for this loss of adult fish is not clear and the data required to unequivocally address the question are not available.

EXPLORATORY DATA ANALYSIS AND SURBA DIAGNOSTICS

TRAC Presentations: Exploratory Data Analysis (EDA) of Survey and Catch Information for Eastern Georges Bank Cod. TRAC Working Paper 2013/05.

SURBA Diagnostics of the Consistency of Survey and Catch Information for Eastern Georges Bank Cod. TRAC Working Paper 2013/06.

Presenter: Noel Cadigan
Rapporteur: Liz Brooks

Term of Reference

Explore a full range of pertinent assessment methods for estimating current abundance and exploitation rate, in particular, to address the issue of retrospective bias.

Presentation Highlights - Exploratory Data Analysis (EDA) of Survey and Catch Information for Eastern Georges Bank Cod

Exploratory data analyses of the stock assessment input information was presented, primarily to examine for consistency of cohorts in the various indices and the catch information, and also to examine overall total mortality rates. Standardized proportion at age plots for the DFO and NMFS spring and fall surveys, and the commercial catch, all indicate good consistency in age compositions. However, there were some year effects which may cause problems when estimating the strength of year classes in stock assessment models.

Survey catch curves suggested that fish were fully recruited to the NMFS fall survey by age 3, and by age 3-4 for the DFO survey and NMFS spring survey. Fish seemed fully recruited to the fishery at age 3 but this shifted to age 4 starting in the 1990’s. Commercial catch curves indicated that, for all years combined, the total mortality rate was 0.86 with periods of small deviations from this value. For some cohorts there was evidence that total mortality was greater at older ages.

Presentation Highlights - SURBA Diagnostics of the Consistency of Survey and Catch Information for Eastern Georges Bank Cod

SURBA is a cohort model designed to provide stock assessment information using only age-based surveys. SURBA does not use estimates of commercial catches. SURBA provides direct estimates of total mortality rates (Z) and trends in stock size. SURBA estimates of stock size are not absolute; they reflect the scale of the survey indices. SURBA can be used to estimate fishing mortality (F) based on an assumed value for natural mortality, F = Z-M. In this implementation F was assumed to be a separable function of year and age effects.

The Baranov catch equation can be used with SURBA estimates of F to infer trends in catches and the age-composition of the catch. This can then be compared with reported catches and age-composition information as a diagnostic procedure to reveal discrepancies between catches and surveys. Large discrepancies could indicate mis-specifications in M or selectivity assumptions, mis-reporting of catches, etc.

SURBA was applied to DFO RV surveys, ages 1-10, and NMFS spring and fall surveys, ages 1-8. The fully recruited q (age 4+) was assumed to be 1 for the DFO survey so that the scale of SURBA estimates is the same as this index. Catchabilities at ages 1-3 for this survey were also assumed, but with some small adjustments to remove residual patterns. Catchabilities for NMFS spring and fall surveys, and age-effects in F, were estimated but with some light shrinkage applied to encourage estimates to vary smoothly with age. Between-year variations in fully selected F's were also penalized.

SURBA results indicated total stock biomass and SSB declined over the time-series and in 2012 it was the lowest since 1978. Fishing mortalities implied by F = Z – 0.2 varied since 1978 but were at high levels in 2010-2012 relative to the series average of 0.50.

SURBA estimates of catch trends (relative to the mean) were lower than reported catch trends during 1985-1990. Among other reasons, these discrepancies may indicate over-reporting of catch and/or M << 0.2 during 1985-1990. SURBA catch trends were higher than reported catch trends since 1995, and these discrepancies may indicate under-reporting of catch and/or M >> 0.2 during this period. The SURBA F selection pattern was not consistent with the reported catch age composition, implying there is domed selection, or M may be higher than 0.2, among other reasons. Selectivity at age 2 may have changed around 1993.

Discussion

How was the bootstrap executed? The method author (Coby Needle) used a parametric bootstrap, i.e. new parameter values are generated from the point estimate and the hessian matrix. On the SSB plot where all of the points are up at the top of the confidence interval, what does that mean? Explanation: quite often when there were high Zs it led to the bootstrap mean population size being lower. No real good explanation. SURBA only estimates observation error. Has SURBA been tested for projection capabilities? Typically, in ICES, this model was used to estimate Z and trends in SSB, but not for catch advice.

Can you estimate how much "missing catch" would be needed to explain the discrepancy? Yes, need to increase catch by 0.75/0.5 (i.e. increase by 1.5) to bring the two lines into agreement.

The periods where SURBA F and catch do not overlap identify some missing component; and perhaps worthwhile to keep an eye on the 1985-1990 period when reviewing ASAP and VPA. It is not clear how year effects carry through in SURBA. Catch selectivity was fixed at 1 for age 5, but results showed selectivity continued to increase through to older ages. This was not consistent with EDA, which showed consistent decline for catch curves from about age 4 or 5.

Surveys track each other well; Z is around 0.86, more or less.

Conclusion

EDA

- Cohorts track well and ages are consistent among surveys.
- By age 3 fish are fully recruited to the fall survey and by ages 3-4 for DFO and spring survey
- Z~ .86.
- Some cohorts do not see Z increasing for older ages.

SURBA

- Discrepancy between catch statistics and SURBA catch trends since 1995 could be explained by either an increase in M (i.e. F = Z – M) or underreporting of catch, combination of both.
- The period of low SURBA F's in 1986-1990 is not consistent with catch statistics.
- SURBA F selection pattern is not consistent with catch age composition, implying there is domed selection, or M may be higher than 0.2, among other reasons.
- Selectivity at age 2 may have changed around 1993.

VPA MODEL PRESENTATION AND REVIEW

TRAC Presentation: Eastern Georges Bank Cod. TRAC Working Paper 2013/01.

Presenter: Yanjun Wang
Rapporteur: Liz Brooks

Term of Reference

Explore a full range of pertinent assessment methods for estimating current abundance and exploitation rate, in particular, to address the issue of retrospective bias.

Presentation Highlights

The severe retrospective bias has been the main issue with the 2009 benchmark model formulations, "split M 0.2" and "split M 0.5". Trial runs incorporating survey year effect by using survey CV weighted abundance indices or by excluding the years with big tows, or incorporating cohort year effect by excluding the abundance indices of younger ages of the stronger 2003 year class, did not improve the retrospective bias for both models. Also, the abrupt changes of survey q in 1993/1994 were another notable problem with these split survey models. It was concluded that the split model was not worth pursuing.

Analyses using simulated data showed that elevated natural mortality and/or missing catch could cause similar residual and retrospective patterns to those observed for the EGB cod models. A summary of the Canadian fishery monitoring system since the mid-1990s did not support the assumption of a high proportion of missing catch for the Canadian fishery.

The following steps were followed to explore several model formulations with higher M:

- Starting at different ages to estimate M for the years of 1994-2011.
- Estimating M of older age plus groups for 2 time blocks (1978-1993, 1994-2011).

- Fixing M at different values for different age plus groups.
- Estimating separate M for older and younger age groups.
- Fixing M of younger age groups and older age groups at different values.

A suite of diagnostics was used to compare how well the models fit the data and how their results conformed to conventional perceptions of fisheries dynamics:

- Residuals: age, time, cohort patterns.
- Survey catchability: age, time patterns.
- Fishery partial recruitment: age patterns.
- Fit statistics: mean of squared residuals, AICc.
- Fishing mortality with respect to catch: time patterns.
- Retrospective: time patterns.

A model with natural mortality (M) set at 0.8 for ages 6+ from 1994 onward, and all other years and ages at 0.2, with F9 set as the weighted average of F7 and F8 (referred to as "M 0.8" model) was supported. This model had improved residual patterns and reduced the retrospective patterns. The estimated fishing mortality time trend was more consistent with the perception of fishing effort regulations. The estimated survey catchability (q) values were reasonable compared with trawl experiments. Fit statistics (Mean Squared Residuals and AIC) favored the "M 0.8" model.

Although M was difficult to estimate, it was agreed during the 2009 TRAC benchmark meeting that the stronger 2003 year class should be informative about natural mortality at older ages. The total mortality calculated from the 2003 year class was quite high; the tagging analysis also indicated a possible elevated M (although this M is in the context of a closed management unit area). The high M could be proxy of fish emigration or leakage to adjacent areas or hiding in the deep water or imperfect designation of the boundaries for this component.

Discussion

Some uncertainties in selectivity result because very few age 6+ cod are caught.

The forward method was used in these models, rather than Fratio on the plus group. When the Fratio was used with M=0.2, there was a bad retrospective pattern. Sensitivity runs: try M=0.8 with Fratio method.

The tendency is to soak up lack of fit by making things flexible; preference is to use parametric relationships with some a priori functional forms. Some suggestions for testing included:

- A run with a higher M in the first period, maintaining M=0.8 in the second period.
- A proposed sensitivity model of M=0.8 for all ages and all years.

Re-run Discussion – VPA Model

For the run using F for age 10 = F for age 9 and flattop survey q: results in an increase in M (0.96) and a drop in biomass estimates. This is not quite the same as setting PR as flattop.

For the run with M = 0.8 for all ages and years: biomass is estimated as very high in early years and there is a strong retrospective.

The dome in the PR is a concern. There is no reason for 10+ to have lower PR. This is a concern for reference points but is thought not to greatly influence the population for younger ages.

Effort peaked in approximately1993 and declined sharply after. Relative F follows the effort pattern. Survey Z does not decline so M must be replacing F to keep Z high while relative F is low.

In the basic VPA, the q pattern is implausible while in the high M model the q pattern is plausible (overall). The q residuals show the same pattern for both models, but perhaps with a greater magnitude in the pattern for the basic model. The residual bubble plots suggest that high M is a better fit to the data, but it does not get rid of all of the “blocking” in residuals by year.

Retrospective is much improved in M0.8 model. But if M is trending, then the retrospective will reappear with time.

Results from an “M block” model (VPA) indicate M increases over time. This model has not been presented in detail and, while it appears promising, it cannot be reviewed at this time.

Previously it has been shown that an increase in effort occurred to the early 1990’s then went into a sharp decline after 1994. There was no consensus in the meeting that this reflects the current effort trend for the 5Ze fishery.

There was no clear consensus in the room that q being well above 1 is implausible, and the trend in q while troubling to some reviewers is thought by others to perhaps be aliasing something else; again, no clear consensus on the interpretation of this information.

ASAP MODEL PRESENTATION AND REVIEW

TRAC Presentation: A Statistical Catch at Age Stock Assessment Model of Eastern Georges Bank Atlantic Cod (Gadus morhua). TRAC Working Paper 2013/08.

Presenter: Loretta O’Brien
Rapporteur: Heath Stone

Term of Reference

Explore a full range of pertinent assessment methods for estimating current abundance and exploitation rate, in particular, to address the issue of retrospective bias.

Presentation Highlights

Input to the ASAP model is essentially the same as that used in the VPA model and includes the total catch of USA and Canadian fleets, and the catch-at-age and weight-at-age for ages 1-10+ during 1978-2011. Swept-area population estimates derived from indices of abundance include the DFO and NEFSC spring survey estimates for ages 1- 10+ and the NEFSC autumn estimates for ages 1-6. Both natural mortality (M) and maturity were age and time invariant, with M=0.2 and knife edge maturity = age 3 + as in previous EGB cod assessments.

In the ASAP model run a multinomial distribution was assumed for both fishery catch at age and survey age compositions. The catch CV=0.05 and the recruitment CV= 0.5, however, the recruitment deviations were set with lambda = 0, so the deviations did not contribute to the objective function. Additional variance was added to the coefficient of variance (CV) for each survey to improve the diagnostics, i.e., DFO: 0.25, NMFS spring: 0.30, NMFS fall: 0.20 and the four years of the Yankee #41 NMFS spring survey (1978-1981) were not adjusted. Both the fishery and survey selectivity was modeled as ‘flat-topped’. For the fisheries, two selectivity blocks were modeled as single logistic from 1978-1993 and 1994-2011. Adjustment of the effective sample size (ESS) of catch and survey was based on the ‘Ianelli’ plot diagnostics (McAllister and Ianelli 1997).

The model fit to the observed catch is almost exact. The catch age composition exhibits larger residuals in the early time period, with a pattern of negative residuals for age 3. The fit of the predicted indices through the observed DFO survey indices was better during the period 1995-2000 than before or after that period. A pattern of negative residuals in the older age groups during 1986-1995 and in the younger ages during 2000-2011 is apparent in the age composition. The fit of the predicted indices through the NEFSC autumn survey indices did not show any strong patterning, although in recent years the model fit does not bisect the survey confidence bounds for 3 years. The age 1 residuals are large and have positive values in the early years and a negative pattern in the later years, however the older ages do not exhibit this pattern. The fit of the predicted indices through the NEFSC spring (Yankee #36) survey indices indicated, similar to the DFO survey, a series of negative residuals in the late 1980s to 1994 and a series of positive residuals since the mid-2000s. The residuals of the age composition show a pattern of positive residuals in age 2 and negative in age 4 in the early years and the opposite in the later years.

Fully recruited F (unweighted, ages 5+) was estimated at 0.45 in 2011. SSB in 2011 was estimated at 3002 mt, a 9% decrease from 2010. Recruitment (millions of age 1 fish) of the 2003 year class (2.7 million) is now estimated to be smaller than the 1998 year class (3.4 million) and the 2010 year class is estimated at 2.4 million.

A retrospective analysis was performed to evaluate how well ASAP calibration would have estimated F, SSB, and recruits at age 1 for seven years (2004-2010) prior to the terminal year, 2011. Retrospective bias in this model is minimal for F and SSB, but there is a pattern of underestimating recruitment relative to the terminal year estimate. Retrospective rho values, the average of the last 7 years of the relative retrospective peels, were 0.025 for SSB, -0.054 for F5+, and -0.529 for recruitment. Applying a retrospective adjustment ((1/(1+rho)) * estimate) results in 2011 estimates of F=0.48, SSB=2,930 mt, age 1 recruitment = 5.1 million fish.

A yield per recruit (YPR) analysis resulted in F0.1= 0.19 and F40% = 0.19. The current negotiated EGB cod F reference point is FREF =0.18. Long term projections provided the following non-parametric reference points: FREF = 0.18, MSY = 11,059 mt (80% CI: 2,065 mt - 14,180 mt), and SSBMSY = 30,622 mt (80% CI: 25,450 mt - 84,346 mt). Biomass reference points are used for status determination for GB cod in the SARC process but are not applied for management of EGB cod by the TMGC and are presented here as background information only.

Short term stochastic projections at F=0.19 and 2012 catch assumed equal to the quota of 675 mt indicated increasing SSB and catch each year during 2013-2015 as the 2010 year class grows and recruits to the fishery. In 2013 the projected catch is 840 mt and projected SSB is 5,270 mt.

Discussion

The initial presentation of this model was to identify any necessary re-runs to look at the following morning (Wednesday). It was requested that the ASAP be run with M=0.8, with the same splits, to compare with VPA. There was a need to see diagnostics side by side to understand why weightings make such a difference.

Re-run Discussion – ASAP Model

A flattop selectivity was used, however this assumption was questioned because the dome estimated during the initial run was informative and should be considered.

There is no restriction on the recruitment rate in the model. This recruitment assumption seems to be a methodological choice which differs between East and West coast assessments.

The consequences of the choice of CV used in the model set-up were questioned. It was explained that weighting "CVs" are similar to iterative reweighting; it is not simply an arbitrary weighting.

Retrospective pattern: Effective sample size is functioning in the model formation as a weighting factor. Fitting the catch better (high effective sample size) gives a lower population estimate and thus no retrospective.

Sampling of the catch now is better than in the past (measurements/mt). The manner of sampling the catch did not influence the selection of effective sample size for the model; the ESS is a weighting factor which is intended to make the model fit better. Using ESS which varies as the biological sampling has varied over time is a routine strategy in this model parameterization.

ESS has been set very low in this model relative to what is done in west coast assessments where ESS is often 200+. This was characterized as a "data-free model" by Iannelli. Total catch would therefore seem to be the most influential data in the model.

There appears to be a strong time trend in the residuals for spring surveys and a similar, though less strong, pattern in the fall survey residuals. This is consistent with the trend in the bubble plots. The population trend appears to be following the trend in catch rather than in the indices. The selected model has no retrospective, but has RMS on the surveys further from 1. This was a trade-off, but lack of retrospective was the main objective in formulating the model.

General observations on model fits included:

- The ESS output from the Ianelli method should fit the input ESS. According to this approach, the fit is a diagnostic of the weighting factors on the data.
- A decline in biomass over time is predicted using this model. This trend is not observed in the spring survey. The predicted decline is seen in the fall survey.
- The residual age plots for fit to commercial catch data indicate an acceptable fit to the model.
- The pattern in DFO and NMFS spring residuals is similar and shows a clear time trend in pattern. The pattern is less clear for the fall but there is still an age pattern trend in these residuals.
- Catchability (q) is very high. This concerned some of the participants. It was suggested high Q may be aliasing something else.
- Z's observed and predicted do not seem to match well for the DFO survey.

It was generally agreed that fitting the survey indices is the primary measure of goodness of fit for the assessment. There was agreement that there is something that has changed over time. No consensus was reached on the cause of this non-stationarity.

REFERENCE POINTS AND PROJECTIONS

TRAC Presentation: What Direction Should the Fishing Mortality Target Change When Natural Mortality Changes Within an Assessment. TRAC Working Paper 2013.

Presenter: Chris M. Legault
Rapporteur: Lour van Eeckhaute

Terms of Reference

Calculate fishing mortality reference points based on the agreed assessment approach.

Formulate projection procedures for harvest advice based on the agreed assessment approach.

Presentation Highlights

Traditionally, the natural mortality rate (M) in a stock assessment has been assumed to be constant over years and ages. When M increases within an assessment, as has occurred in a number of Canadian cod stocks, the US Gulf of Maine cod stock, and the US Atlantic herring stock, the question arises how to change the fishing mortality rate target (Ftarget). Yield per recruit considerations lead to an increase in the Ftarget, while maximum sustainable yield considerations lead to a decrease in the Ftarget. Neither approach is theoretically superior. Using a model from the recent Gulf of Maine cod assessment, both approaches were examined. Problems were found with both, leading to recommendations to either not allow M to change within an assessment model or if M does change to base the Ftarget on the natural mortality rate considered most appropriate based on the life history traits of the species of interest.

Discussion

It was asked why the change in F40% with increasing M was not linear. The presenter answered that it is due to the influence of the stock/recruit relationship.

Questioned as to why the west coast assessment staff use constant M rather than varying M, the presenter answered that it is difficult to estimate M and they may adjust F or M. It was clarified that constant M is used for both the assessment and Fref. The presenter was not sure how a situation where M has varied, as it has for northern cod, would be handled. It was noted that FMSY and M interactions were complicated.

It was suggested that a possible harvest strategy, if M is higher on older fish, is for the fishery to target older fish. In that case, what would be the effect on the stock/recruit relationship and on BMSY? The yield per recruit method of estimating Fref would indicate fishing old cod harder with higher M but there is the danger that fishery selectivity could still hit younger ages too hard. It is expected that there would be fewer recruits if the population is losing older fish at a high rate. In the sGSL, cod are expected to go extinct if M remains at the current very high level. The decision to be more precautionary and fish at very low levels in the hope that they won’t go extinct and that conditions for survival will improve has been in this area. The directed cod fishery is currently closed in the sGSL.

The US management regime is required to follow the limit references for the whole of Georges Bank cod which includes the eastern portion. For the eastern portion of GB, Fref is a negotiated value, based on F40% and F0.1. If it is decided to reconsider the Fref for this stock, negotiation will occur within the TMGC.

TRAC Presentation: Eastern Georges Bank Cod. TRAC Working Paper 2013/01.

Presenter: Yanjun Wang
Rapporteur: Lou van Eeckhaute

Presentation Highlights

The current fishing mortality reference point was derived from spawner and yield per recruitment analyses. By coincidence, F40%spr =F0.1=0.18; the same value currently used for Fref. Using the average PR of 1994-2011 from the “basic VPA” model formulation and the average fishery and spawning stock weight at age for 1994-2011 as input, a recalculation based on the same analysis produced the same value as the current Fref, F40%spr =F0.1=0.18.

For the “M 0.8” model, the calculated F0.1 was 0.46 and F40%spr was 0.53, much higher than the current Fref. Considering the heightened importance and influence of the stock-recruitment relationship when natural mortality is high, the age-disaggregated Sissenwine-Shepherd production model was used for derivation of FMSY. For the SSB and recruitment relationship analysis, the parametric Beverton-Holt stock-recruit model did not fit the observed data in a meaningful way. A non-parametric loess smoother was applied to characterize the stock-recruitment relationship. For biomass less than any observed value, recruitment would be expected to decline with biomass and eventually go to the origin (0, 0). For biomass greater than the observed value, recruitment would be expected to neither increase nor decrease. The estimated value of FMSY was 0.125. Given the uncertainties with the stock-recruitment relationship and high natural mortality, a proxy for F reference points, F90%MSY (Beverton 1992) which could produce 90% of MSY with much less fishing effort, was calculated as 0.11 and recommended as the Fref.

For the projection, if F90%MSY =0.11 was set as the Fref, a combined Canada/USA catch of 1,100 mt would correspond to a 25% probability that F will exceed Fref, while a catch of about 250 mt would result in a neutral risk that 2014 adult biomass would not increase by 10%. The 2014 adult biomass would increase by 11.3% if there was no catch in 2013.

Discussion

The information presented indicated that a high M increases the likelihood of declining population trajectories and that a lower Fref is one method for managers to reduce this likelihood.

It was questioned whether management had any special preference for F90%msy. In reply, the presenter answered “no” but there is a need to consider the stock/recruit relationship in order to reduce the likelihood of stock declines. However, this metric is arbitrary, just as the choice of F0.1 is for the yield per recruit method of estimating reference points.

CONSENSUS SUMMARY

TRAC felt compelled to come up with one model to meet the Terms of Reference. There was no consensus on the most appropriate model. However, based on the two model options presented, the consensus was to provide advice based on the VPA M0.8 model until the next benchmark because it provides better survey residual diagnostics.

A consequence analysis to understand the risks associated with assumptions of this model and the alternative model examined (ASAP M0.2) will be completed for the June assessment.

The analysis will consist of estimating the projected catch at Fref as if each model were correct and examining the consequences to expected biomass as if the opposite model were correct. This consequence analysis would be similar to the method used in SARC 55

Issues to be aware of when using the VPA 0.8 model:

- Non-stationarity in the system is accepted
- Tagging analysis on 4+ cod (greater than 50 cm) supports an M higher than 0.2 across the tagging time series.
- While it was accepted that M plays a role in the non-stationarity of the system, we have not reached a consensus that all the non-stationarity was in M.
- The possibilities hypothesized include confounding effects from (M - emigration), q - selectivity), and unreported catch.
- There is concern on the impact of this increase in M on how reference points and advice will be provided. For example, the Fref=0.18 is inconsistent with model derived reference points from the VPA M0.8 model
- Two models were accepted in the 2009 benchmark model; one which proposed an M of 0.2 and the other which used an M of 0.5 both with surveys split into two time periods. The M0.5 improved residual and retrospective issues compared to previous assessment models. We have now agreed to increase M to 0.8, without sufficient understanding of the biological mechanism. There is concern that the model formulation will not be stable.

Before the next benchmark it is necessary that:

- DFO and Woods Hole labs work together to develop a common or set of common assessment frameworks where assessment model hypotheses can be tested using the same model.
- This framework environment may be current ASAP, VPA, MSE or some other combination of assessment modelling environments.
- The labs put priority on development of this common assessment framework environment so that before the next benchmark meeting the consequences of the various alternative hypotheses can be examined and a preferred assessment model for providing the most robust advice can be identified.

Details on model reviews, non-stationarity and M, and reference points:

<u>VPA Model Conclusions</u>

VPA M0.8 Model is preferred over the BASIC VPA model:

- Better residual patterns.
- Improved retrospective patterns.
- q values more consistent with previous assessment analyses and trawl experiments.
- Fit statistics (MSR and AIC) favour VPA M 0.8 model over the BASIC VPA model.

Uncertainties:

- Uncertainty discussions focused around plausibility of M increasing from 0.2 to 0.8 in 6+ , e.g. why this would occur from age 5 to 6 when there was appreciable overlap in the sizes of these ages.
- Uncertainty in the stability of the model: 2009 benchmark used an increasing M (0.5 with surveys split) to solve a problem and now it has increased to 0.8.

- Overfitting of the models (ADAPT vs. ASAP) was not examined and sufficiently explained, especially in comparison of one model to the other.
- A consensus around the biological mechanism that would lead to this increase has not been reached.

<u>ASAP M0.2 Model Conclusions</u>

Preferred model is Run 3f.1:

- The root mean square error was acceptably close to 1 and improved the retrospective pattern.
- Ianelli plots were used as a diagnostic that the best weight (defined as effective sample size) was chosen.
- Residuals for catch indicated a good fit to the data.
- Catch age composition residuals indicated a good fit to the data.
- q patterns among the surveys were consistent with previous models and expectations based on cod biology and survey methodology.

Uncertainties:

- Uncertainties in this formulation are associated with survey residuals and q values.
  - Trends were observed in survey residuals
  - Survey residuals indicated a decline in the index that was not observed in the data
  - Residual patterns for age composition of the surveys also indicated biases in model fits to surveys.
- Uncertainty was associated with the absolute values of q.
  - For example, a q of 2.5 for a survey means that gear is fishing 100% of everything in front of the net and herding at a high rate.
  - However, it was also hypothesized that the model is increasing q to account for changes associated with some other factor that is exhibiting non-stationarity in this system.

Discussion on Natural Mortality Rate (Plausibility that M has increased to M=0.8):

While the TRAC did not reach consensus that all the non-stationarity in the system was the result of M, there was a good discussion on the mechanisms that would be important to understand. There was insufficient time to resolve these points among those in attendance and the points provided below represent the views (pros and cons that support/contradict the M change) expressed during the meeting rather than consensus conclusions of the meeting. Sources of uncertainty, which by definition are not yet informative for evaluating the possibility of an M change, are also identified.

Life-history and Cod Condition and Increasing M:

<u>Pros</u>

- Results from fitting length at age data to a von Bertlanffy growth function indicated that the current population is dominated by relatively small fish with high K and low Linf. The assumption is that smaller fish are subject to higher predation than larger fish.
- There is a seasonal aspect to condition and it is not unusual to find seasonal differences. The lowest condition would be expected in the spring and this is when you would see mortality.

- Fulton's K calculated using gutted weight from post-spawning cod sampled during the 2013 DFO survey indicated that most fish > 55cm had a condition factor below 0.8, a value near those of fish in the starvation experiments in the lab (<0.7, Lambert and Dutil 1997).

Cons

- In the SARC 55 benchmark review, the WG investigated several life-history analyses and also tagging results to evaluate the M assumption. In a meta-analysis of life history-based estimates, M estimates ranged between 0.21 - 0.45.
- In the framework meeting tagging analysis indicates that M has not changed over time on GB.
- M high (~0.8) in both time periods on 5Z.
- M low on 4X early period, high in later period.
- Uncertainties associated with these conclusions are outlined above in: Estimates of mortality and migration from Atlantic cod tag-recovery data in NAFO areas 4X, 5Y, and 5Z in 1984-1987 and 2003-2006 TRAC Working Paper 2013/02
- A decrease in condition in the spring but not the autumn, as evidenced by Fulton's K create uncertainty on a hypothesis for a shift in life history parameters.
- Noted that maximum age as high as 15 has been observed in the commercial fishery as recently as 2011, and age 12 in the more recent years, which suggests comparable natural mortalities relative to earlier in the time series.

Predation and Increasing M:

Pros

- Seals have increased in abundance in the Georges Bank area (surveys in GoM)
- Seals from Sable Island, especially males migrate to Georges Bank in February and March, this is the time when fish aggregate for spawning and fish condition is poor.
- Adult males have been found to consume a higher proportion of large groundfish than females in sGSL

Cons

- Based on trawl survey data, Link (2012) noted that directed piscivory of cod by other fish was not common, with less than 200 identifiable cod in over 550,000 stomachs observed the survey time series.
- Studies to date suggest that M due to fish predation is likely low and is focused on juvenile and smaller size groups

Uncertainties:

- Firm estimates on the size of the current herds are not available.
- Additionally, while seals are known to prey on cod, they are generalist feeders and the importance of cod in the diet of Gulf of Maine area grey seals is unknown.

Reference Point Setting:

The decision from this meeting was to (1) run projections with the current Fref (0.18), (2) something less than that (perhaps around the 0.11 = 0.9MSY, and (3) something greater than the current Fref. The assessment leads are to decide on the values. It would be a TMGC decision on whether or not to proceed with a Fref negotiation.

CONCLUSIONS

- The two models indicate different strategies for developing reference points. There is concern on the impact of this increase in M on how reference points and advice will be provided. For example, the Fref=0.18 is inconsistent with model derived reference points from the VPA M0.8 model
- If the system is non-stationary, using F40% from the M=0.8 model would increase the likelihood of stock decline, but, for the M=0.2 model (ASAP model), the current Fref is appropriate.
- Because the system is non-stationary and there is no consensus on appropriate modelling choices, the role of the assessment is to ensure that fishery managers are informed of the consequences of the decisions made about reference points. The consequences could be expressed as projections several years into the future using various levels of F (e.g., 0.11, 0.18) or, build a rationale for lowering Fref to facilitate biomass rebuilding. The consensus was that assessment leads should pick the most meaningful values.
- This consequence analysis will consist of estimating the projected catch at Fref as if each model were correct and examining the consequences to expected biomass as if the opposite model were correct.

LITERATURE CITED

Benoît, H.P., and Swain, D.P. 2011. Changes in Size-dependent Mortality in the Southern Gulf of St. Lawrence Marine Fish Community. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/039. iv + 22 p.

Benoît, H.P., Swain, D.P., Bowen, W.D., Breed, G.A., Hammill, M.O., and Harvey, V. 2011. Evaluating the Potential for Grey Seal Predation to Explain Elevated Natural Mortality in Three Fish Species in the Southern Gulf of St. Lawrence. Mar. Ecol. Progr. Ser. 442: 149-167.

Breed, G.A., Bowen, W.D., McMillan, J.I., and Leonard, M.L. 2006. Sexual Segregation of Seasonal Foraging Habitats in a Non-migratory Marine Mammal. Proc. R. Soc. B. Biol. Sci. 273: 2319-2326.

Chouinard, G.A., Swain, D.P., Hammill, M.O., and Poirier, G.A. 2005. Covariation Between Grey Seal (*Halichoerus grypus*) Abundance and Natural Mortality of Cod (*Gadus morhua*) in the Southern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 62: 1991-2000.

DFO. 2011. Impacts of Grey Seals on Fish Populations in Eastern Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/071.

Gavaris, S. 1999. ADAPT (ADAPTive Framework). User’s Guide. Vers. 2.1.

Gascoigne, J.C., and Lipcius, R.N. 2004. Allee Effects Driven by Predation. J. Appl. Ecol. 41: 801-810.

Harvey, V., Hammill, M.O., Swain, D.P., Breed, G.A., Lydersen, C., and Kovacs, K.M. 2012. Winter Foraging by a Top Predator, the Grey Seal Halichoerus grypus, in Relation to the Distribution of Prey. Mar. Ecol. Progr. Ser. 462: 273-286.

Hunt, J.J., and Hatt, B. 2000. Population Status of Eastern Georges Bank Cod (Unit Areas 5Zj,m) for 1978-2000. DFO Can. Sci. Advis. Sec. Res. Doc. 2000/58.

Hunt, J.J., and Johnson, T.L. 1999. Population Status of Eastern Georges Bank Cod (Unit Areas 5Zj,m) for 1978-99. DFO Can. Sci. Advis. Sec. Res. Doc. 1999/77.

Hunt, J.J., Hatt, B., and O'Brien, L. 2004. Population Status of Eastern Georges Bank Cod (Unit Areas 5Zj,m) for 1978-20005. TRAC Ref. Doc. 2004/02.

Lambert, Y., and Dutil, J-D. 1997 Condition and Energy Reserves of Atlantic Cod (*Gadus morhua*) During the Collapse of the Northern Gulf of St. Lawrence Stock. Can. J. Fish. Aquat. Sci., 54: 2388-2400.

McAllister, M.K., and Ianelli, J.N. 1997. Bayesian Stock Assessment Using Catch-age Data and the Sampling-importance Resampling Algorithm. Can. J. Fish. Aquat. Sci. 54:284-300.

O'Boyle, R., and Sinclair, M. 2012. Seal–Cod Interactions on the Eastern Scotian Shelf: Reconsideration of Modelling Assumptions. Fish. Res. 115-116 (2012): 1-13.

Rafferty, A.R., Brazer Jr., E.O., and Reina, R.D. 2012. Depredation by Harbor Seal and Spiny Dogfish in a Georges Bank Gillnet Fishery. Fish. Manage. Ecol. 19: 264–272.

Swain, D.P., and Mohn, R.K. 2012. Forage Fish and the Factors Governing Recovery of Atlantic Cod (*Gadus morhua*) on the Eastern Scotian Shelf. Can. J. Fish. Aquat. Sci. 69: 997-1001.

Swain, D.P., Jonsen, I.D., Simon, J.E., and Myers, R.A. 2009. Assessing Threats to Species at Risk Using Stage-structured State-space Models: Mortality Trends in Skate Populations. Ecol. Appl. 19: 1347-1364.

Swain, D.P., Benoît, H.P., Hammill, M.O., McClelland, G., and Aubry, É. 2011. Alternative Hypotheses for Causes of the Elevated Natural Mortality of Cod in the Southern Gulf of St. Lawrence: The Weight of Evidence. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/036. Iv + 33 p.

Van Eeckhaute, L., and Gavaris, S. 2004. Determination of Discards of Georges Bank Cod from Species Composition Comparison. TRAC Ref. Doc. 2004/04: 27p.

Wang, Y., and O'Brien, L. 2012. Assessment of Eastern Georges Bank Cod for 2012. TRAC Ref. Doc. 2012/05: 83p.

APPENDIX 1: LIST OF PARTICIPANTS AND REVIEWERS

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Brooks, Liz	NOAA / NMFS/NEFSC
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D'Entremont, Claude	Inshore Fisheries / MG < 65 ITQ
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APPENDIX 2: TERMS OF REFERENCE

Transboundary Resources Assessment Committee
Benchmark Assessment of Eastern Georges Bank Cod

April 2013

TERMS OF REFERENCE

Context

The TRAC was established in 1998 to peer review assessments of transboundary resources in the Georges Bank area and thus to ensure that the management efforts of both Canada and USA, pursued either independently or cooperatively, are founded on a common understanding of resource status. While stock assessment results are needed routinely to serve the management system, it is not practical to evaluate the assessment approach each time the assessment is conducted. Instead, reviews of the assessment approach (benchmark assessments) are conducted periodically, generally at a separate meeting. The previous two TRAC benchmark reviews for cod were conducted in February 2002 and in 2009 (January- data meeting, April- model review).

At present, the USA assessment for the whole of Georges Bank is conducted independently from the TRAC assessment of eastern Georges Bank. There is some concern that differing assessment approaches may make reconciliation of results difficult.

Objectives

This meeting will have two primary objectives: 1) to review the assessment framework for the Eastern Georges Bank cod management unit (5Zjm for Canada), with the agreed benchmark model formulation to be used in the June 2013 TRAC for 5Zjm cod, and 2) to discuss criteria for timing of and allowable changes to TRAC benchmark model assessments. More specific objectives for the meeting include:

- Review tagging data for application in stock assessment, particularly with respect to estimation of natural mortality.
- Examine relevant ecological and biological data such as, but not limited to, growth, maturity, fecundity, recruitment, environmental factors, and trophic interactions to estimate natural mortality.
- For the Canadian groundfish fishery operating in NAFO Division 5Z - 6 during 1978 – 1996, summarize the conclusions on discarding from the contemporary Research Documents, where available. Where no previous review has been done, or discarding was suspected, evaluate discards (unreported catch) of cod and associated uncertainties.
- Explore a full range of pertinent assessment methods for estimating current abundance and exploitation rate, in particular, to address the issue of retrospective bias.
- Calculate fishing mortality reference points based on the agreed assessment approach.
- Formulate projection procedures for harvest advice based on the agreed assessment approach.
- Assess stock dynamics to investigate potential changes in stock productivity.
- Discuss criteria to determine: 1) when a benchmark assessment should be conducted, and 2) what degree of modification is acceptable to make to a benchmark model formulation during an update assessment.

Outputs

TRAC Proceedings, which will document the details of the benchmark
TRAC Reference Documents

Participants

DFO Maritimes scientists and managers
NMFS Northeast Region scientists and managers
Canadian and USA fishing industry
USA State and Canadian Provincial representatives
Northeast Fisheries Management Center representatives

APPENDIX 3. AGENDA

Transboundary Resources Assessment Committee
Eastern Georges Bank Cod Benchmark Assessment

Hachey Conference Centre
St. Andrews Biological Station
St. Andrews, NB

9-11 April 2013

DRAFT AGENDA

9 April – Tuesday

9:00 – 9:15	Welcome and Introduction (Chairs)
9:15 – 9:30	Discards from the Canadian Groundfish Fishery: 1978-1996 (D. Clark)
9:30 – 10:30	Review of Tagging Data (T. Miller)
10:30 – 10:45	Break
10:45 – 11:30	History of Assessment Formulations (Y. Wang)
11:30 – 1:00	Lunch
1:00 – 1:45	Natural Mortality Related Ecological Data (Y. Wang)
1:45 – 2:30	VPA Random Walk of Natural Mortality (D. Swain)
2:30 – 3:00	Exploratory Data Analysis and SURBA diagnostics (N. Cadigan)
3:00 – 3:15	Break
3:15 – 4:30	VPA Model Presentation and Review (Y. Wang)
4:30 – 5:30	ASAP Model Presentation and Review (L. O'Brien)

10 April – Wednesday

9:00 – 9:15	Review of Day One (Chairs)
9:15 – 10:30	Discussion
10:30 – 10:45	Break
10:45 – 12:00	Reference Points and Projections (Y. Wang)
12:00 – 1:30	Lunch
1:30 – 3:00	Development of Consensus Report
3:00 – 3:15	Break
3:15 – 5:30	Development of Consensus Report (continued)

11 April – Thursday

9:00 – 9:15	Review of Day Two (Chairs)
9:15 – 10:30	Review and Finalization of Consensus Report
10:30 – 10:45	Break
10:45 – 11:30	Review and Finalization of Consensus Report

APPENDIX 4: CRITERIA FOR EVALUATION AND MODIFICATION OF COD, HADDOCK AND YELLOWTAIL BENCHMARKS

Term of Reference

Discuss criteria to determine:

- when a benchmark assessment should be conducted, and
- what degree of modification is acceptable to make to benchmark model formulation during an update assessment.

Without new information or modeling approach requesting a benchmark would not be productive. During a TRAC update, changes to a benchmark model formulation would be presented as a sensitivity run and evaluated to see if a future benchmark would be required based on points outlined below. In all future TRAC assessments, a cumulative summary of changes to the current benchmark model will be included in the assessment research document.

- Accumulation of data changes result in substantial change in catch advice relative to the benchmark formulation.
- Change in either data or model results in substantial change in perception of stock size or stock structure.
- On a regular basis, e.g. every five years, evaluate whether a benchmark review would be justified.
- New data becomes available, e.g., new survey, that would affect model results.
- Model results are inconsistent with observations; poor diagnostics.

In a TRAC update, if a sensitivity run suggests that a benchmark is required the TRAC will present catch advice for both models with rationale as to why the sensitivity run would be preferred in the interim.

APPENDIX 5: AGENDA (REVIEW OF CRITERIA)

Transboundary Resources Assessment Committee
Meeting to Review Criteria for Evaluation and Modification of Cod, Haddock and Yellowtail Benchmarks

Hachey Conference Centre
St. Andrews Biological Station
St. Andrews, NB

11 April 2013

DRAFT AGENDA

1:00 – 1:15	Introduction and Background (Chairs)
1:15 – 3:00	Review of Proposed Criteria
3:00 – 3:15	Break
3:15 – 5:00	Development of Consensus Report